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Članek / Article

Assessment of Sustainable Indicators for Drinking Water Management in Slovenian Municipalities

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Abstract:

Research Question (RQ): Drinking water management is becoming an increasingly challenging, sustainable management of this natural resource can be judged using appropriate indicators. The research question is with which indicators it is possible to measure the sustainability of the management of the public utility service of drinking water supply in major Slovenian municipalities.

Purpose: For this purpose we have developed a composite index of sustainable drinking water management, which includes indicators with the environmental, economic, social and institutional dimension of sustainable development.

Method: Qualitative research included a review of professional and scientific literature and a comparative analysis of foreign authors' articles and researches and studies carried out. In the research we used the method of comparing, summarizing, compilation and qualitative analysis.

Results: The results of the survey are useful for municipalities, operators of drinking water utilities, decision makers in sectoral policy, policy makers, non-governmental organizations, professional and general public. Municipalities can be easily acquainted with the situation and consequently with responsibility, with the necessary supervision and strategic direction of drinking water management. On the basis of the results, public utility service providers of drinking water supply can focus on identifying important environmental impacts and responses, and consequently on those natural resources that can be maintained in a sustainable way through sustainable management..

Organization: The results of the survey are useful for municipalities, operators of public drinking water supply service, decision makers in sectoral policy, decision makers, non-governmental organizations, professional and general public. Municipalities can be easily acquainted with the situation and consequently with responsibility, with the necessary supervision and strategic direction of drinking water management. On the basis of the results, public utility service providers of drinking water supply can focus on identifying important environmental impacts and responses, and thus on those natural resources that can be maintained in a sustainable way through sustainable management.

Society: The results of the research are useable by the general public, since area of drinking water management is inextricably linked with the whole society and with each individual.

Originality: A set of indicators in the context of a composite index of sustainable drinking water management.

Limitations / further research: The research is concentrated on Slovenian municipalities, but the same research could be done with the providers of drinking water supply as well**.**

Keywords: sustainability, drinking water management, indicators, municipalities, public utility services of drinking water supply, assessment framework DPSIR.

1 Introduction

Water is by far the most complex natural resource for management. Drinking water management is becoming an increasing challenge also due to the limited nature of the natural

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resource as the rising demand for water, the uneven distribution of water resources and the depletion of aquifers, the increasing frequency of water stress, and, more recently, the growing climate change.

Complexity is typical for all levels - from the local, regional and national levels to the global community, but in this article we focused on the local communities in Slovenia and tried to answer the question by which indicators can be measured the sustainability of the management of the public utility of drinking supplies water in major Slovenian municipalities.

In this paper, we have taken a step towards better understanding and coping with the challenges of holistic management and drinking water management at the local level and respecting the principles of sustainability. The aim of the research is to create a useful model that enables the assessment of the sustainability of drinking water management in Slovenian municipalities. This requires an appropriate framework of indicators that describes and communicates the current situation and provides data on drinking water management, and allows action and provides important information in decision-making processes. To this end, we have developed a composite index of sustainable drinking water management, which includes indicators with the environmental, economic, social and institutional dimension of sustainable development. The multi-criteria model of sustainable drinking water management is the platform of the composite index of sustainable drinking water management. Within the framework of the analysis, a minimum number of indicators are defined that provide an assessment of the sustainability of drinking water management and apply to larger Slovenian municipalities.

Indicators are based on the five-fold assessment framework, known as the DPSIR, which includes driving forces (D), pressures (P), state (S), impacts (I), and responses (R). The composite index of sustainable drinking water management with a set of individual indicators must ensure consistency and comparability of data over time and a comparison between major Slovenian municipalities, as well as scientific, technical and communication guidelines for the sustainable management of water resources.

The research will help bridge the gap between science, profession and politics through the proposed system of indicators and placement in the auditory five-part framework, and allow dispersed reporting information to be aggregated into a standardized form, which can be a powerful tool for decision-makers in the management of drinking water. This allows us to achieve a wide range of goals, from the right to drinking water and to the provision of a quantity of sufficient and high quality drinking water, up to river basin management to sustainable ecosystem management. The proposed model of sustainability drinking water indicators can be used for further research and redesign based on user preferences and needs.

2 Theoretical framework

Over the past two decades, it has increasingly been recognized that water-related crises are often also management crises, not just a crisis due to inadequate drinking water supplies or climate change, Rogers and Hall (2003, p. 15) note from the summary World Water Congress in The Hague in 2000. Water governance refers to the range of political, social, economic and administrative systems that are place to develop and manage water resources and the delivery of water services at different levels of society (ibid., p. 16).

Water governance includes multiple tiers of government, their formal regulations and policies, as well as market forces, public-private alliances, and informal mechanisms such as community norms.

Where the underlying governance system is weak, stakeholders are unable to efficiently and effectively respond to pressures like pollution, growing water demand, and land use change. Moreover, requires a rethinking of existing water governance frameworks to support cross-sectoral interactions and coordination of a wide range of public and private stakeholder groups (Bertule et al., 2017, p. 57).

Drinking water management involves not only a performance assessment, which may be useful and often necessary for analysis from an economic point of view, but is an important understanding of sustainable drinking water management. At the same time, measuring sustainable drinking water management helps to identify the gaps in social, environmental, economic and institutional systems. One of the fundamental challenges we recognize is that local communities, as owners of water infrastructure, do not monitor or use any methodology for assessing sustainable drinking water management in their municipality area. At the national level, Slovenia's strategy for the development of Slovenia is the ninth goal, as one of the twelve fundamental goals of sustainable management of natural resources (Strategija razvoja Slovenije 2030, 2017, p. 40), which is monitored for Slovenia by three indicators: the share of utilized agricultural land, the quality of watercourses and the ecological footprint.

An effective and targeted use of indicators for information and process guidance is needed to assess sustainable drinking water management. Framework identifies, categorizes, and organizes those factors deemed most relevant to understanding some phenomenon (McGinnis, 2011, p. 170). There are several fundamental reasons for using a conceptual framework to select indicators in river basin planning and management. Arguably the most important reason is that the framework helps users define (and understand) the problems they want to address.? The framework ought to reflect the users’ goals for conducting an assessment and as described in the next sections, there are different types of frameworks available depending on these goals. The relevance of the framework concept should be (Bertule et al., 2017, p. 6):

- based on sound theory that in turn helps select indicators in accordance with their policy relevance. It explains why particular indicators are needed for issue identification, policy analysis and tracking performance (OECD, 2008). Relying on sound theory and clearly outlining the connections between indicators and problems on the ground is critical for indicators in river basin planning and management because they will be used as a measure of the 'success' of a particular policy or approach,

- simplicity is also important and a conceptual framework can help users to stay focused and to identify a set of indicators that collectively measures phenomena of interest without being exhaustive or redundant. As the number of indicators increases, so too will the administrative costs of collecting and maintaining data, and the difficulty of interpreting and attributing changes to indicators.. Collectively, the indicators should maximise unique, relevant information while minimising redundancy,
- finally, using a conceptual framework can help promote transparency about what is being measured and why. This transparency serves internal and external audiences, and is essential to the perceived credibility of the indicators. After all, indicator selection reflects personal and institutional biases for what must be known, technical considerations and knowledge constraints as well as progress on society's goals and is therefore unavoidably normative.

Identifying an appropriate framework begins with identifying specific problems that stakeholders face within the basin and collective goals for improving or maintaining conditions. Among these frameworks, there are inevitable overlaps in terms of technical concepts as well as specific indicators. Most of the frameworks are anthropocentric but they vary in their emphasis on human needs and socioeconomic drivers. Some tend to be more normative and action-oriented while others are more diagnostic and help users analyse a situation without prescribing specific interventions. The frameworks also vary in their complexity, particularly the degree to which they help analysts account for interactions between social and ecological systems or their contextual drivers. We summarise these frameworks below (see Table 1).

Table 1. Types of conceptual frameworks and their applications.

Framework	**Strength**	**Limitation(s)**
DPSIR/CCA	Uses cause-effect logic; decades of applications in environmental management	Simplistic, unidirectional (linear) relationships; less balanced treatment of issues besides environmental degradation
Ecological Health	Strong scientific underpinning; oriented towards consumptive and non consumptive uses of water resources	Data intensive; less balanced treatment of human concerns
Institutional Performance	Highlights importance of governance issues; most amenable to setting tangible and achievable management goals	Data intensive; weak conceptual and empirical underpinnings
Risk Assessment	Decades of application in water resources management	Hazard identification and vulnerability characterisation are not easily integrated; goals narrowly defined to reducing risk
System Sustainability	Emphasises interactions and integrative aspect of indicators	Complex to develop; complicated to understand; limited empirical underpinnings
Value and Threat Analysis	Stakeholder driven process that results in a level consensus amongst stakeholders	Results depend on which stakeholders have been consulted. Requires sound stakeholder mapping

Using indicators for improved water resources management - guide for basin managers and practitioners (Bertule at al., p. 12), 2017, UN Environment – DHI Centre on Water and Environment, World Wildlife Fund, Conservation International, Luc Hoffmann Institute, University of Maryland Center for Environmental Science and the Global Environment Facility.

The above frameworks represent only one set of options based on frequently used indicator frameworks for basin management. Other frameworks may be considered depending on the needs and purpose of the indicator selection. Regardless of the exact indicator framework selected, creating effective indicators to support decision making in river basin governance and management is more likely to be useful and usable if the underlying frameworks:

- reflect social, economic and environmental goals in river basin governance and management
- are effective at breaking tunnel vision so that they support identification of critical issues, risks and solution entry points across the social, environmental and economic systems in river basins
- fit into existing systems of knowledge, technologies and governance as defined by the stakeholders
- are flexible enough to be reviewed and altered as critical issues change in river basins so they remain supportive of decision making
- add clarity to help navigate complexity; indicators can be useful in explaining, defining and navigating complexity of the systems required
- are fit for purpose, selecting and applying indicator frameworks should fit the purpose and circumstances of the basin, ensuring a balance between sound theory and a pragmatic approach that helps to achieve the goals.

The use of the DPSIR framework is most often mentioned in Slovene professional literature, and the advantage is recognized primarily in the use of the logic of causes and consequences in the management of the environment and thus also of water. In Slovenia, ARSO uses this framework of assessment and summarizes it according to the recommendations of the European Environment Agency.

Despite being widely used, these frameworks are subject to criticisms. One is that they assume linear cause-effect relationships, which tend toward oversimplification of complex human-environment interaction. Additionally, the DPSIR framework has been criticised for not clearly distinguishing drivers and pressures from one another and for impacts being too focused on human health (Bertule et al., 2017, p. 8). Another is that indicator categories are inconsistently defined (Gari, Newton and Icely, 2015, p. 75), while the framework must continue to evolve into a more sophisticated tool for analysing and assessing environmental problems, as improvement and development are an integral part of science.

On the other hand, the framework of the *Ecological Health* draws attention primarily to the measurement and conservation of healthy aquatic ecosystems, with the assumption that the services related to water and to which people are relying are provided.

The very concept of the ecological state of water covers both the diversity of living spaces and the diversity of life communities. It could also be called the biological state of a particular water body, which is better understood only if we know the support elements that are determined and analysed as physical and chemical parameters. The ecological status describes the quality of the structure and functioning of aquatic ecosystems. Recognizes five classes of condition: very good, good, moderate, bad and very bad. The final assessment of the ecological condition is based on the principle that the "worst information" determines the state of the body of water (Toman, 2015, p. 9).

Ecological health frameworks use a variety of biophysical and chemical proxies to compare a freshwater ecosystem (Bertule et al., 2017, p. 8).

However, ecosystems represent a much wider picture, they are made up of non-living factors (water, light, air, heat, mineral substances, soil or soil) and living environmental factors (plants, animals, microorganisms, human). The ecological status of water is limited only to aquatic ecosystems.

Governance and institutional performance are framed by indicators beyond the biophysical and chemical properties of water and the social and economic issues of drinking water management. The principles are clustered around three main dimensions (OECD, 2018, p. 5):

- effectiveness of water governance relates to the contribution of governance to defining clear sustainable water policy goals and targets at different levels of government, to implement policy goals, and to meet expected objectives or targets,

- efficiency of water governance relates to the contribution of governance to maximising the benefits of sustainable water management and welfare at the least cost to society,
- trust and engagement in water governance relate to the contribution of governance to building public confidence and ensuring inclusiveness of stakeholders through democratic legitimacy and fairness for society at large.

Risk assessment is a familiar approach in the fields of water and environmental resource management. Risk assessments typically consist of two major steps – hazard identification and vulnerability characterisation. There are a number of variations of similar frameworks, some looking to separate the dimensions of risk in three categories – Hazard, Vulnerability and Exposure (in this case the two dimensions of Vulnerability are looked at in more detail, i.e. separating the Vulnerability and Exposure). Concerns about climate change are driving further interest in water-related risk assessments. (Bertule et al., 2017, p. 10)

A *System Sustainability* framework emphasises human dependence on water resources, the links among social, economic, and environmental subsystems (i.e., the 'three pillars' of sustainability), and the intergenerational aspect of sustaining a resource base. Like the DPSIR and CCA approaches, the system sustainability approach attempts to account for causal links, although this framework also calls for more explicit accounting of the 'system' being assessed and all of the feedbacks and interactions within that system. Consequently, as a set of indicators this framework can be more challenging to construct and more complex to understand than the other frameworks (ibid, p. 10).

The *Value and Threat Assessment* framework requires direct engagement of stakeholders (e.g. in a workshop setting) to define the values within the basin. The strength of the approach lies in drawing on stakeholder knowledge and identifying issues of direct importance to basin stakeholders. Ideally, the process should be facilitated to ensure best practice science-based indicators are considered and issues represented do not weigh unevenly towards some aspects more than others. (ibid, p. 11)

The conceptual framework of assessment provides focus and guidelines for the selection of indicators, coherence and links at the level of the thematic group and subgroup of indicators make it important to co-shape. The key thematic indicators for sustainable drinking water management are consolidated into ten areas (Figure 1). The category of users of water (topic 10) is the largest number of indicators, namely six, while the minimum performance indicators are defined with the least indicators - with only two indicators. We understand this as meaningful; the sustainability of water management is the key condition of the consumers or consumers of water.

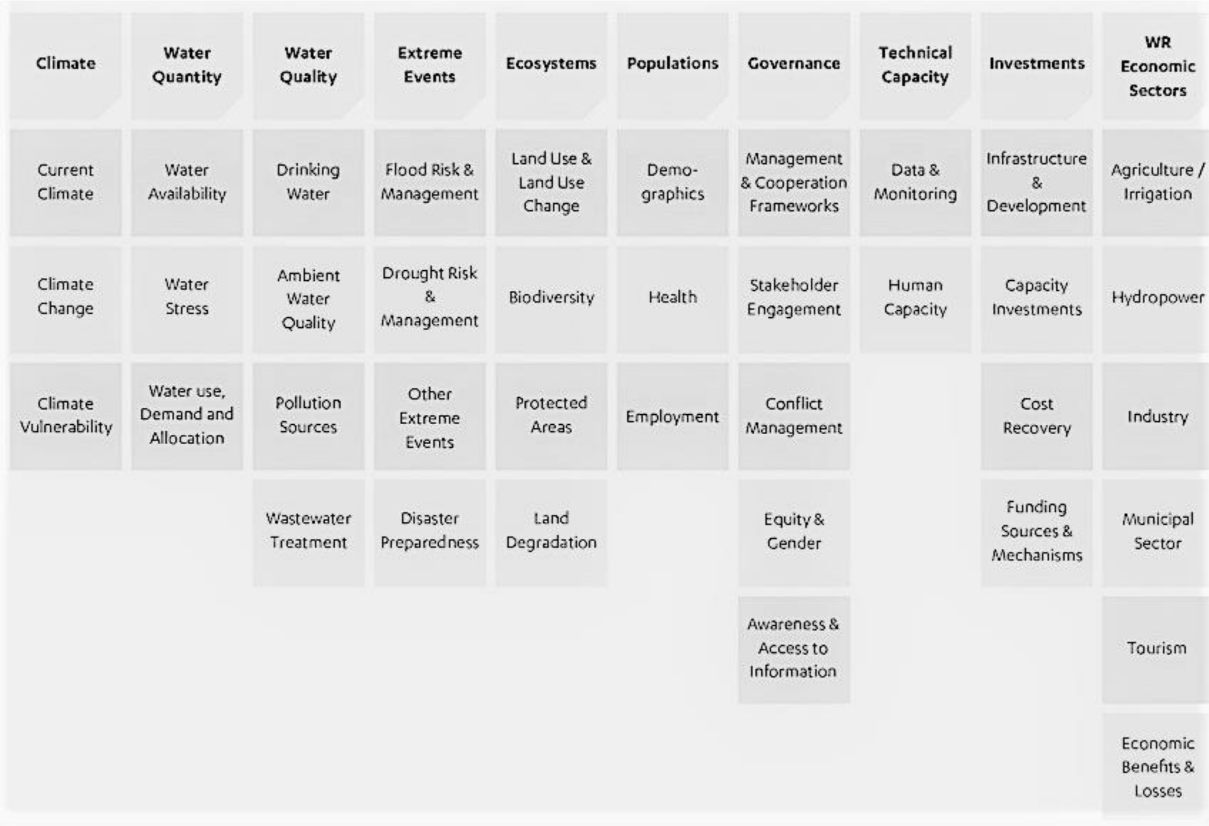

Figure 1. Comprehensive thematic indicator framework for integrated water resources management. Adapted from "Using indicators for improved water resources management - guide for basin managers and practitioners", by Bertule et al., 2017, UN Environment – DHI Centre on Water and Environment, World Wildlife Fund, Conservation International, Luc Hoffmann Institute, University of Maryland Center for Environmental Science and the Global Environment Facility, p. 53.

The presented framework of thematic indicators is based on integrated water resources management and addresses water resources management issues, including those in related sectors (eg. energy, agriculture, tourism) and socio-economic variables. The purpose of this categorization is the reflection of all the main thematic indicators and subcategories that appear in various investigated frameworks of indicators and can serve as a starting point for the development of a thematic framework of indicators.

The proposed thematic indicator framework can be used in the following ways (ibid, p. 54):

1. Establishing an overview of groups and subgroups to be considered when selecting indicators. This can be particularly helpful where managers and stakeholders are new to indicator use for resource management and in basins where no indicator based monitoring or management schemes are in place (i.e. avoiding 'starting from scratch').
2. Building on the proposed framework by adding and removing indicator categories (and subcategories) in a way that tailors the framework to the specific needs of the users. The overall principle is to start from a larger set of indicator thematic categories and sub-categories and narrow this down to a smaller, relevant set.

3. Creating an indicator selection ‘checklist’ to make sure that relevant aspects of resource management are considered by including for example at least one indicator per category/ subcategory.

To implement and test this indicator selection and framework-building approach, an online Water Indicator Builder tool has been developed.

Selecting appropriate indicators is an important step in developing the model. More than 240 indicators closely related to water and / or water resources are currently in use, of which 170 are important for the use and management of drinking water (Pires et al., 2015, page 77)

There are many indicators potentially available to monitor each issue and the number is growing rapidly with developments in science (e.g. possibilities offered by earth observation data for water resources) and emerging local and regional water monitoring arrangements. Often the challenge is to narrow them down to a minimum set.. Too many indicators can cloud interpretation and exceed financial and human resources for collection and analysis while too few will result in insufficient information to characterise the system as outlined in the framework, potentially leading to erroneous conclusions and ill-advised policy decisions.. It is also important to narrow the selection to best possible indicators for the purpose – i.e. ones that are scientifically robust but also meaningful in the context of the intended use. Choosing the wrong indicator can not only be inefficient in providing the necessary information but also lead to distorted decisions, and by giving unnecessary attention to some aspects, lead to counterproductive actions or unintended consequences. Meaningful, in this context, also includes indicators that are relevant and clearly understandable to stakeholders, as this can increase the chances of triggering action on the ground. (Bertule et al., 2017, p. 14)

At a minimum, there should be a sufficient number of indicators to answer the question of whether basin management is moving towards the right direction and the set outcomes, goals or targets to be achieved (Kusek and Rist 2004).

From the theoretical perspectives of sustainable development and research related to drinking water management, we have observed models developed from 2000 to the present. When choosing, we focused on research that differentiates the concept of sustainability in the management of drinking water in the urban area. This ensures the appropriateness of using the model and its validity also in the larger Slovenian municipalities. We analysed the following seven models:

(1) The Swedish research program "Sustainable Urban Water Management" is a model composed of five sustainability criteria (health and sanitation, social and cultural, environmental, economic, functional and technical) and a set of 19 indicators (Hellstrőm, Jeppsson, Kärrman, 2000 , pp. 316─318)

(2) SWITCH (Sustainable Water Management Improves Tomorrow's Cities' Health) is an integrated water management concept, 69 indicators are classified into five areas (access to drinking water, access to the sewage system, surface and groundwater quality, flood in vulnerable areas, general sustainable characteristics of the urban water system). The model is characterized by the fact that the indicators are defined within the PSR model (P - pressures, S - state, R - responses) (Van der Steen, 2011, pp. 35-40)
(3) Green Growth Indicators is defined by five groups: the socio-economic context and the characteristic of growth; environmental and medium-term productivity of the economy; natural resources; the environmental dimension of quality of life; economic prospects and policy responsiveness. Green growth indicators, 31 comparable indicators, are a subset of indicators of sustainable development, which do not include a social point of view, but only environmental and economic (OECD, 2017, p. 135─137)
(4) The City Blueprint Sustainable Water Management Index comprises 25 indicators in seven categories: water quality, solid waste treatment, basic water supply services, waste water treatment, infrastructure, climatic robustness and government policy and governance (Koop & van Leeuwen, 2015, p. 5660)
(5) Sustainable Index for Integrated Urban Water Management (SIUWM) includes a political dimension in urban governance. The multi-criteria model encompasses the socio-cultural dimension, economic, environmental, political and institutional-technological, it is the 20 main indicators and 64 variables (De Carvalho et al., 2008, p. 146).
(6) The Sustainable Development of Energy, Water and Environment Systems Index (SDEWES) is defined as the sustainability of the development of the three systems, the composite indicator combines seven dimensions and includes 35 indicators (Kilkiş, 2016, p. . 222─234).
(7) The Multi-Critical Model of Sustainable Water Management (ISWUM) is based on social, economic, environmental and institutional sustainability. The set of 24 water management indicators is located in the DPSIR framework (Pires, 2015, p. 146─176).

There is a great deal of information in European and world literature on research in the field of sustainable drinking water management and studies in which models with systematic indicators are developed, while in Slovenia there is no evidence of sustainable drinking water research. There are studies either in terms of sustainable (sustainable) development or management, while united approaches can not be traced.

Based on the definition of the research question and the presented theoretical starting points, we have set the main hypothesis that with the composite index of sustainable drinking water management, the sustainability of the management of the public utility service of drinking water supply in larger Slovenian municipalities can be measured.

In the article, we assume that the composite index of sustainable drinking water management, which includes six key indicators and 66 variables, enables the assessment of the sustainability of drinking water management in major Slovenian municipalities. We have developed the following hypotheses:

H1: indicators are defined within a sustainable concept,

H2: the integrity of the composition of indicators is ensured in the conceptual framework,

H3: the content dimension of the indicators is based on the ten thematic areas,

H4: indicators are simple and useful at the level of major Slovenian municipalities.

The model was used to create a questionnaire and conducted a survey and successfully evaluated the sustainability of drinking water management in major Slovenian municipalities.

3 Method

In a transparent scientific article, we used a literature study to address the topic and examined the area of sustainable drinking water management according to the framework of judgment and the thematic framework indicators in individual models. We reviewed and compared the articles of foreign authors and those carried out research and conducted studies related to sustainable drinking water management in the period from 2000 onwards. When searching for materials, we used electronic sources, keywords or phrases from the content or title of the article, we searched exclusively in English, in Slovenian practice we did not find relevant models. Through the review, we gained insight into the narrow selection of seven different models of sustainable drinking water management and the precise set of indicators defined in each model.

The research was based on the assessment of seven different models and was carried out on the basis of qualitative research, we used the method of comparison, summation, compilation and qualitative analysis. As shown in the survey plan (Figure 2), we examined selected models from a sustaining point of view, based on audit frames and thematic indicators. The composite index is the final product.

The set of drinking water management models and the indicators used in the data analysis process were evaluated by *Using indicators for improved the water resources*, from 2017 prepared by researchers from UN Environment – DHI Centre on Water and Environment, World Wildlife Fund, Conservation International, Luc Hoffmann Institute, University of Maryland Center for Environmental Science and the Global Environment Facility.

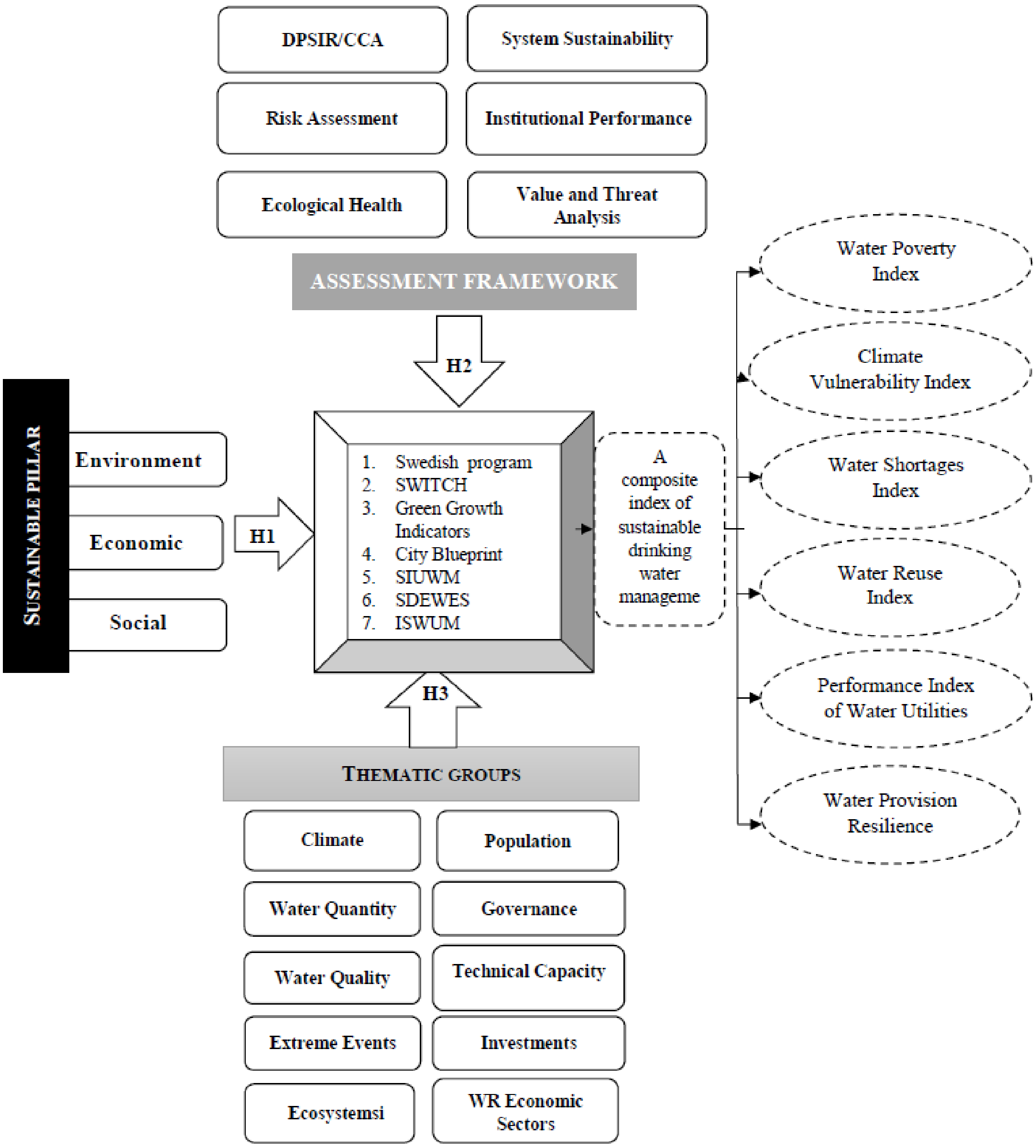

Figure 2. Model of research

The analysis of the models was carried out on the basis of checking the indicators regarding the sustainable concept, within environmental, economic and social pillar. We continued with the study of the integrity of the indicators, depending on the different assessment frameworks presented in the theoretical starting points. However, how are the content areas defined, based on the inclusion of individual thematic indicators of drinking water management, were carried out on the basis of the recommended ten content assemblies. The set of indicators of the composite index of sustainable drinking water management (ISWM) was the final result that provided the answer to the research question.

4 Results

4.1 Assessment framework

Assessment frameworks in selected seven models of sustainable drinking water management are evident from Table 2 and indicated in a spreadsheet labeled x or partial integration x^2. We have not presented the indicators individually, as there are large scale sets.

Table 2. Conceptual framework in models of sustainable drinking water management

Conceptual framework / Model	Number of indicators	DPSIR/ CCA	Ecological Health	Institutional Performance	Risk Assessment	System Sustainability	Value and Threat Analysis
Swedish program	19		x			x	x/$_2$
SWITCH	69	x*	x	x/$_2$	x	x	x/$_2$
Green Growth Indicators	31		x	x/$_2$	x/$_2$	x/$_2$	
City Blueprint	25		x	x/$_2$	x/$_2$	x	x
SIUWM	64		x	x	x/$_2$	x	x
SDEWES	35		x	x		x	
ISWUM	24	x	x	x	x	x	x/$_2$

Note *: assessment of PSR (P - pressures, S - state, R - responses) and ZK (external indicators) / x /2 partial

4.2 Framework of thematic indicators

Thematic indicators included in selected models of sustainable drinking water management are shown in Table 3, in the individual categories "x" is for categories that are defined in the set of indicators in each model with at least one sub-category from the respective content area.

Table 3. Thematic indicators in models of sustainable drinking water management

Thematic Indicators / Model	Number of indicators	Climate	Water Quantity	Water Quality	Extreme Events	Ecosystems	Populations	Governance	Technical Capacity	Investments	WR Economic Sectors
Swedish	19	x	x	x	x	x			x		
SWITCH	69	x	x	x	x	x	x	x	x	x	
Green Growth	31	x	x	x	x	x	x		x	x	x
City Blueprint	25	x	x	x				x	x	x	
SIUWM	64		x	x	x	x	x	x	x	x	x
SDEWES	35	x	x	x		x		x		x	
ISWUM	24	x	x	x	x	x	x	x	x	x	x

4.3 The multi-criteria model of sustainable drinking water management

The multicriteria model of sustainable drinking water management has been recognized as the most suitable for assessing the sustainability of drinking water management in Slovenian municipalities on the basis of validation of indicators, evaluated matrix and structured research, and methodologies and case studies carried out by authors. The starting point is in a four-dimensional sustainable system, the indicators are defined in the framework of the DPSIR assessment and include most of the indicators from ten thematic sets. The selected multi-criteria model comprises 24 indicators (Table 4).

Table 4. The multi-criteria model of sustainable drinking water management

	Indicator	DPSIR	Included/ note
1.	**Water Poverty Index**	P, S, I, R	✓
2.	**Climate Vulnerability Index**	P, S. I. R	✓
4.	**Water shortages**	I	✓
3.	**Water Reuse Index**	P, S	✓
5.	Water Footprint	P	n/a
6.	Incidence of worms, scabies, trachoma, diarrhoea	I	no phenomena
7.	**Performance Index of Water Utilities**	S	✓
8.	Access to Improved Sanitation	I	not typical
9.	Proportion of Urban Population Living in Slums	P, S	not typical
10.	Fraction of the burden of ill-health from nutritional deficiencies	I	no phenomena related to water
11.	Social and Economic Impacts from Drought	I	there is no integrated social and / or economic treatment
12.	Incidence of cholera	I	no phenomena
13.	Causes of food emergencies	I	n/a
14.	Ecological footprint	P	no measurements at the local level
15.	Progress towards achieving IWRM target	R	n/a
16.	**Water Provision Resilience**	S, R	✓
17.	Major drought events and their consequences	I	no measurements at the local level
18.	Relative Water Stress Index	P, S	no measurements at the local level
19.	Index of Non-sustainable Water Use	P,S	n/a
20.	Water sector share in total public spending	R	no measurements at the local level
21.	Country’s dependence ratio	P, S, R,	no measurements at the local level
22.	Pro-poor and pro-efficiency water fees	S, R	not characteristic (prescribed methodology)
23.	Water topics in school curriculum	S	no deviations (the school system is unified)
24.	Total water storage capacity	P, S R	no measurements at the local level

»Multi-criteria and Participatory Approach to Socio-Economic, Environmental and Institutional Indicators for Sustainable Water Use and Management at River Basin Level«, Pires, A., 2015, *Doctoral thesis,* Annexes – Indicator Profile Sheets, pp. 146-176.

4.4 The composite index of sustainable drinking water management

The model framework consists of six main indicators, which are classified into the Sustainable Drinking Water Management Index. The model is based on social, economic, environmental and institutional sustainability, it includes the framework of the DPSIR assessment and the framework of thematic indicators. In the multi-criteria model of sustainable drinking water management, all aspects of sustainability relevant to the assessment of drinking water management are addressed, and in the Sustainable Drinking Water Management Indicator, the DPSIR assessment framework and the thematic framework are shown in the indicators (Table 5).

Tabela 5. The composite index of sustainable drinking water management

	Main indicators (number of variables)	Framework DPSIR	Thematic framework
1.	Water Poverty Index (21 variablaes)	P, S, I , R	climate, water quantity, water quality, ecosystems, populations, governance, technical capacity, WR economic sectors
2.	Climate Vulnerability Index (1variable)	P, S. I, R	climate
3.	Water shortages (1 variable)	I	water quantity
4,	Water Reuse Index (3 variables)	P, S	water quantity, populations, WR economic sectors
5.	Performance Index of Water Utilities (4 variables)	S	water quality, populations, governance, technical capacity, investments, WR economic sectors
6.	Water Provision Resilience (36 variables)	S, R	Water quantity, water quality, extreme events, ecosystems, population, governance, technical capacity, investments

5 Discussion

In this scientific article, we analysed various models selected according to the criterion of sustainable drinking water management, and examined them according to the framework of assessment and inclusion of thematic indicators. In this, we relied on guide that identifies the most common audit frameworks and content indicators. In seven models we dealt with indicators that evaluate the sustainability of drinking water management according to the DPSIR/CCA assessment framework, Ecological Health, Governance and Institutional Performance, Risk Assessment, System Sustainability and Value and Threat Analysis. These are the most useful frameworks in studies and practice, are based on solid theoretical starting points and provide a choice of the most important factors for the management of drinking water and help to ensure transparency about what is measured and why. We did not display detailed lists of indicators and variables, but only their number (Table 2 and 3). The model of sustainable drinking water management in cities (SWITCH) comprises the largest set of 69 indicators and 19 in the Swedish research program, the smallest.

As we pointed out, it is essential for models to include the dimensions of a sustainable system because we have chosen them according to this basic (sustainable) principle. The exception is the Green Growth Index, the indicators are a subset of indicators of sustainable development, since they do not include a social point of view. The ecological status of waters is common to all models, while risk assessments are not included in the Swedish research program and the model of the composite index of the energy, water and environmental system (SDEWES). The latter also does not include value and risk analysis; this assessment can not be confirmed even for the green growth index. Management and institutional action is not only covered in the Swedish research program, but also partly in the sustainable drinking water management model in cities (SWITCH), the Green Growth Index and the City Blueprint project.

Comparison of models based on the inclusion of thematic indicators (Table 3) points to the disadvantage of the model of the composite index of the energy, water and environmental system (SDEWES), which deals with five content categories, representing half, and the Swedish research program and the City Blueprint (6 categories of 10).

The Sustainable Drinking Water Management in Cities (SWITCH) model does not cover most of the thematic indicators that define sectoral water users (eg agriculture, hydroelectric power stations) as the model focuses on cities. The Green Growth Index is deficient in the content of management indicators. In the 2017 Indicator of Green Growth Indicators (OECD, 2017, pp. 135-137), we also find that indicators and management approaches need to be developed. In the model of sustainable integrated water management in cities (SIUWM), where there is a set of 64 indicators, the climate category does not address climate change or climate vulnerability. It also includes vulnerability to natural disasters, risk management and mitigation. All ten thematic indicators are represented in the multi-criteria model of sustainable drinking water management (ISWUM).

When considering and assessing the seven models, we found that the best way to estimate the sustainability of drinking water management with the ISWUM multi-criteria model of sustainable drinking water management, which consists of 24 indicators. When designing the sustainable drinking water management index, we checked the groups to be considered in the choice of indicators and fenced the categories that are not user needs, i.e. local communities.

The composite index of sustainable drinking water management is based on the multi-criteria model, which was optimized according to the characteristics of the Slovenian territory (Table 4). The final set of indicators of the composite sustainable drinking water management index comprises six key indicators (Table 5) and 66 variables, which are not specifically mentioned. The assumption that the composite index of sustainable drinking water management enables the assessment of the sustainability of drinking water management in major Slovene municipalities was verified with four hypotheses. The first hypothesis that all indicators are within a sustainable (sustainable) concept, we have confirmed. Indicators in the composite index of sustainable drinking water management include environmental, economic and social dimensions. The second hypothesis, which examined the integrity of the composition of indicators, is confirmed by the involvement of the DPSIR assessment, which is also recommended by the profession in Slovenia, the consistency can also be confirmed on the basis of other audit frameworks. The third hypothesis focuses on the content different thematic dimension of the indicators. The composite index of sustainable drinking water management covers all ten thematic aspects, so this hypothesis is confirmed. The fourth hypothesis that indicators are simple and useful at the level of major Slovenian municipalities is confirmed on the basis of the results of the conducted research using the questionnaire addressed to the larger Slovenian municipalities. Accessibility of information and simplicity of indicators make a significant contribution to the usefulness of the model and provide insight into the management of drinking water at the municipal level, thus providing support in the decision-making processes and in the implementation of measures. It is important that this is a manageable number of indicators that are clearly defined and understandable. The process of data acquisition at the municipal level does not require additional time, municipalities (and administrative units) have the databases needed to assess the best approximation of how successful they are in achieving the objectives of sustainable drinking water management on the basis of a composite index of indicators.

In the discussion of various conceptual models of sustainability of drinking water management, for which we find that they are still developed and used as a means of simplifying and generalizing the key characteristics of the complexity of drinking water management, we have come to the following conclusions. Conceptual models, which allow for thoughtful communication, reflection and decision-making with the growing uncertainty of a changing world, are not universal. The diversity of drinking water management solutions and the focus on sustainable discourse opens up a debate on complex systems that are too long and complicated for the usability and comprehensibility of users - including municipalities and providers of public utilities of drinking water supply.

It is necessary to develop mutual understanding and cooperation between representatives of different disciplines and stakeholders from very different environments - politics, science, business and local practices. The use of the presented model with clear and understandable indicators for assessing sustainable drinking water management can be a step towards understanding and clarity of goals. By selecting a minimum number of indicators, we tried to capture the complexity of the system and provide the necessary information to support decision-makers both at local community level and decision makers in the water sector.

6 Conclusion

The concept of sustainability changes in society and becomes, in fact, a social imperative, since environmental developments in recent years point to a degraded natural balance, and the need for natural resources that are constrained are now exceeding environmental capabilities. Changed global environmental conditions require an effective natural resource conservation system and, as we have presented, the emphasis is on such activity at local community level, as the monitoring of indicators of green growth (three indicators) is not sufficient at the country level.

To summarize the findings from the evaluated models, they are characterized by a sustainable concept, but they differ in the scope of indicators, the audit framework as well as the inclusion and the treatment of specific content areas. The selected model of sustainable drinking water management is designed as an index of six indicators, organized on the content bases and theoretical framework. Indicators are sufficient for criteria such as clarity and comprehensibility, usefulness for policy and decision making, comparability, availability of quality data (including for time series), but also cost-acceptance.

We have repeatedly emphasized that drinking water management is complex, it involves the interweaving of different disciplines, economic and environmental connections, and, last but not least, the emphasis on the legal aspect in the social context. In Slovenia, it is not possible to detect the introduction of new research approaches or models to place the construct of sustainability of drinking water management at the level of local communities, while in the Slovenian Development Strategy 2030 sustainable (sustainable) management of natural resources comprises only three indicators (agricultural land, quality of watercourses , ecological footprint). Also, it is recommended that the model be transferred to the local level, since the owners of the municipal infrastructure (municipalities) and direct providers of drinking water supply are responsible for the sustainable management of drinking water. In order to ensure the sustainability of drinking water management, the state is responsible only for declarative purposes.

The presented model of sustainable drinking water management addresses potential issues and indicators that relate to the management of resources in an integrated way - environmental components, including those in related sectors of the economy (eg. energy, agriculture) and social variables. The model is a reflection of all the main thematic indicators and subcategories that appear in different indicator frameworks. As a contribution of science, we also recognize the simple understanding and clarity of goals and the shift of the abstract concept of sustainability into a measurable state of dynamic social, economic and environmental changes.

The article discusses the model of indicators of sustainable drinking water management, which can be widely used - for local communities, public utility service providers for drinking water supply, actors in sectoral and cross-sectoral policies, non-governmental organizations, professional and general public. On the level of the organization (municipalities and public utilities), the use of such a model can lead to the identification of significant environmental impacts and responses, the design of measures in cases of overload, and acceptable policies and the achievement of sustainable development objectives based on results (estimates) with selected indicators of sustainable drinking water management and conservation of aquatic natural resource.

It is important to be aware that water is the core of sustainable (sustainable) development, as ministers stressed in the declaration adopted at the 7th World Water Forum in Korea in July 2015.

The multi-criteria drinking water management model can be used in further surveys and re-shaped based on user preferences or needs. The model is designed in the direction of checking the sustainability of drinking water management in Slovenian municipalities, which are the owners of municipal infrastructure and leave the management to the operators of this commercial public service. We believe that it would be sensible to carry out research at this level. An interesting survey, which would include the analysis of the results of the survey of municipalities and operators of the public utility for the supply of drinking water in the same time period.

References

1. De Carvalho, S. C. P., Carden, K. J., Armitage, N. P. (2008). Application of sustainability index for integrated urban water management in Southern African cities: Case study comparison – Maputo and Hermanus. Water Sa 35(2). Retrieved from https://www.ajol.info/index.php/wsa/article/viewFile/76727/67165
2. Hellström, D., Jeppsson U., Kärrman E. (2000). A framework for systems analysis of sustainable urban water management. Environmental Impact Assessment Review, 20, 311-321. Retrieved from http://dx.doi.org/10.1016/S0195-9255(00)00043-3
3. Kilkis, Ş, Sustainable Development Of Energy, Water And Environment Systems Index For Southeast European Cities, Journal of Cleaner Production (2015), doi: 10.1016/j.jclepro.2015.07.121.
4. Koop, H. A. in Leeuwen, C. J. (2015). Assessment of the Sustainability of Water Resources Management: A Critical Review of the City Blueprint Approach. Water Resources Management, 29(15), 5649-5670. doi: 10.1007/s11269-015-1139-z
5. Kusek, Z. J. & Rist, R. C. (2004). Ten Steps to a Results–Based Monitoring and Evaluation System. The International Bank for Reconstruction and Development. Washington: The Word Bank. Retrieved from https://www.oecd.org/dac/peer-reviews/World%20bank%202004%2010_Steps_to_a_Results_Based_ME_System.pdf

6. McGinnis, M. D. (2011). An Introduction to AID and the Language of the Ostrom Workshop: A Simple Guide to a Complex Framework. The Policy Studies Journal, 39(1), 169─183. https://doi.org/10.1111/j.1541-0072.2010.00401.x
7. OECD (2008). Handbook on constructing composite indicators:methodology and user guide. Paris: OECD. Retrieved from https://www.oecd.org/sdd/42495745.pdf
8. OECD (2017). Green Growth Indicators 2017. Paris: OECD. doi.org/10.1787/9789264268586-en
9. OECD (2018). OECD Water Governance Indicator Framework Paris: OECD. Retrieved from https://www.oecd.org/regional/OECD-Water-Governance-Indicator-Framework.pdf
10. Pires, A. (2015). Multi-criteria and Participatory Approach to Socio-Economic, Environmental and Institutional Indicators for Sustainable Water Use and Management at River Basin Level (doktorska naloga). Katalonska politehnična univerza. Barcelona. Retrieved from https://is.upc.edu/en/events/doctoral-thesis-public-defence-multi-criteria-and-participatory-approach-to-socio-economic-environmental-and-institutional-indicators-for-sustainable-water-use-and-management-at-river-basin-level
11. Rogers, P., & W. Hall, A. (2003). Effective Water Governance. Technical Committee (TEC) The background papers No. 7. Stockholm: Global Water Partnership. Retrieved from https://www.gwp.org/globalassets/global/toolbox/publications/background-papers/07-effective-water-governance-2003-english.pdf
12. Toman, M. Vodni dnevi 2015. Zakaj določamo ekološko stanje vodnih teles in ne njihove kakovosti? Podčetrtek, 15.-16. oktober 2015 (str. 7─15). Ljubljana: Slovensko društvo za zaščito voda in Inštitut za javne službe.
13. UN Environment – DHI Centre on Water and Environment, World Wildlife Fund (WWF-US), Conservation International (CI), Luc Hoffmann Institute (LHI), University of Maryland Center for Environmental Science (UMCES) and the Global Environment Facility (GEF). (2017). Using indicators for improved water resources management - guide for basin managers and practitioners. Retrieved from http://ian.umces.edu/pdfs/ian_report_560.pdf
14. Van der Steen, P. (2011). Application of Sustainable Indicators with the framework of Strategic Planning for Integrated Urban Water Management. Sixth Framework Programe 2002-2006. Retrieved from: http://www.switchurbanwater.eu/outputs/pdfs/W1-1_CALE_MAN_D1.1.7_Indicators_Manual.pdf
15. Vlada Republike Slovenije (2017, 7th December). Strategija razvoja Slovenije 2030. Retrieved from http://www.vlada.si/fileadmin/dokumenti/si/projekti/2017/srs2030/Strategija_razvoja_Slovenije_2203.pdf
16. 7th World Water Forum. (2015). Ministerial Declaration. Retrieved from http://www.worldwatercouncil.org/fileadmin/world_water_council/documents/press_releases/Ministerial_Declaration_7th_World_Water_Forum_1304_Final.pdf

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Mihaela Rudar Neral je doktorandka študijskega programa Menedžment kakovosti na Fakulteti za organizacijske študije v Novem mestu, magistrirala je iz študijskega programa Medkulturni menedžment na Fakulteti za uporabne družbene študije v Novi Gorici, diplomirala na Ekonomsko poslovni fakulteti v Mariboru. Zaposlena je v komunalnem in gradbenem podjetju Kostak v Krškem kot analitik poslovnih procesov. Pri svojem delu je usmerjena v kakovost življenja, na delovnem mestu preučuje kakovost storitev na področju

storitev oskrbe s pitno vodo, v okviru analize poslovnih procesov pa se posveča zanesljivosti in prilagodljivosti gospodarskih javnih služb, ki zagotavljajo storitve v okviru služb varstva okolja. Na Fakulteti za organizacijske študije (FOŠ) pripravlja doktorsko disertacijo s področja vzdržnega upravljanja z vodami v večjih slovenskih občinah. Sodeluje na strokovnih konferencah v okviru komunalnega gospodarstva ter znanstvenih konferencah ter objavlja članke v domačih publikacijah.

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Povzetek:
Kazalniki v okviru presoje vzdržnosti upravljanja s pitno vodo v slovenskih občinah

Raziskovalno vprašanje (RV): Upravljanje s pitno vodo postaja vse večji izziv, vzdržno (trajnostno) upravljanje tega naravnega vira je mogoče presoditi z uporabo primernih kazalnikov. Raziskovalno vprašanje je, s katerimi kazalniki je mogoče meriti vzdržnost upravljanja gospodarske javne službe oskrbe s pitno vodo v večjih slovenskih občinah.
Namen: V ta namen smo oblikovali sestavljeni indeks vzdržnega upravljanja s pitno vodo, ki vključuje kazalnike z okoljsko, gospodarsko, družbeno ter institucionalno razsežnostjo vzdržnega (trajnostnega) razvoja.
Metoda: Kvalitativna raziskava je obsegala pregled strokovne in znanstvene literature ter primerjalno analizo člankov tujih avtorjev in izvedenih raziskav ter študij. Pri raziskovanju smo uporabili metodo komparacije, povzemanja, kompilacije ter kvalitativne analize.
Rezultati: Na podlagi preučevane literature in raziskav na obravnavanem področju smo opredelili sestavljen indeks vzdržnega upravljanja s pitno vodo, in sicer z obvladljivim številom kazalnikov, pri tem pa odgovorili na raziskovalno vprašanje. Kazalniki temeljijo na petdelnem okviru presoje, t. i. okviru DPSIR, ki vključuje gonilne sile (D), obremenitve (P), stanja (S), vplive (I) in odzive (R). Sestavljeni indeks vzdržnega upravljanja s pitno vodo temelji na indeksu vodne revnosti, podnebne ranljivosti, pomanjkanja vode, povečane uporabe vode, zmogljivosti in prožnosti občin in gospodarskih javnih služb oskrbe s pitno vodo. Strukturiran indeks z naborom šestih glavnih kazalnikov obsega ključne spremenljivke, razporejene v okviru deset tematskih področij.
Organizacija: Rezultati raziskave so uporabni za občine, izvajalce gospodarske javne službe oskrbe s pitno vodo, odločevalce v sektorski politiki, oblikovalce ukrepov, nevladne organizacije, strokovno in širšo javnost. Občine so lahko na enostaven način seznanjene s stanjem in posledično z odgovornostjo, s potrebnim nadzorom in strateško usmeritvijo upravljanja s pitno vodo. Izvajalce gospodarske javne službe oskrbe s pitno vodo pa se lahko na osnovi rezultatov usmerja v prepoznavanje pomembnih vplivov in odzivov na okolje in s tem na tiste naravne vire, ki jih lahko z vzdržnim upravljanjem ohranjajo v dobrem stanju.
Družba: Rezultati raziskave so uporabni za širšo javnost, saj je področje upravljanja s pitno vodo neločljivo povezano s celotno družbo in z vsakim posameznikom.
Originalnost: Nabor kazalnikov v okviru sestavljenega indeksa vzdržnega upravljanja s pitno vodo.

Omejitve/nadaljnje raziskovanje: Raziskava je osredotočena na slovenske občine, enako raziskavo pa bi bilo umestno narediti tudi z izvajalci gospodarske javne službe oskrbe s pitno vodo.

Ključne besede: vzdržnost, upravljanje s pitno vodo, kazalniki, občine, izvajalci gospodarske javne službe oskrbe s pitno vodo, okvir presoje DPSIR.